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COMPLETE SPECIFICATION

Well Drilling Fluid

We, SHELL DEVELOPMENT COMPANY, a corporation organized under the laws of the State of Delaware, United States of America, and having a place of business at 100, Bush Street, San Francisco, California, United States of America, (Assignee of RUDOLF AUGUST HENKES, a Subject of the Queen of The Netherlands and a resident of Mene Grande, State of Zulia, Venezuela), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the drilling of oil and gas wells and is more particularly concerned with the use and composition of an improved drilling fluid.

The circulation of a drilling fluid or mud through the borehole is necessary in rotary drilling in order to lubricate the drill bit, to keep the borehole clean by carrying the cuttings to the surface, to prevent blow-outs by holding down high formation pressures, and to form on the walls of the borehole a sheath or cake which prevents the drilling fluid from escaping into porous formations.

Drilling fluids commonly used heretofore were water-base fluids, for example clay suspended in water, and oil-base drilling fluids, for example calcium carbonate suspended in oil.

The chief disadvantages of water-base fluids are as follows: Their gel-forming and plastering, that is sheath-forming, properties are subject to deterioration upon contamination by salts from formation brines. In drilling through so-called heaving shale formations, the water of the fluid causes a swelling of the shale and a collapse of the borehole walls. In drilling through oil-bearing formations, the high hydrostatic pressure of the drilling fluid column may force the water of the fluid deep into the formation, thus plugging this formation. This contaminating water is not expelled by the flow of oil back into the borehole after the well is put on production, but often remains adhering to the sand grains, thus greatly reducing the productivity of the well. In the same manner, this water contaminates the cores which it is customary to obtain during drilling, and thus makes it impossible to determine accurately the true fluid content of these cores, and of the formations from which they are obtained. Finally, the mudsheath formed by water-base fluids sometimes impedes the flow of oil from the producing formation into the well. When the oil is produced from an open or uncased hole, this can be remedied by washing or cutting the mudsheath away. When, however, the oil is produced through a perforated or slotted casing, liner or screen, it is extremely difficult to wash the sheath away from behind the screen. Sloughing particles of the mudsheath clog the perforations of the screen during production, and greatly reduce the inflow of the oil to the well.

The chief disadvantages of the oil-base fluids are as follows: Their cost is greatly in excess of that of water-base muds. Their preparation involves considerable mixing difficulties in the field, since they require various additives, such as lampblack, soaps, blown asphalt, etc., to regulate their gel-forming and plastering properties. They furthermore have an unfavorable temperature viscosity coefficient, that is, their viscosity is usually high at well-head temperatures, which imposes a strain on the pumping equipment, and is low at high bottom hole temperatures, which permits the sediment and cuttings to settle at the bottom of the well, and makes it impossible to obtain a clean hole without extensive cleaning. Finally, the oil-base fluids, as well as the mudsheaths formed thereby, are electrically non-conductive, which makes it extremely difficult to obtain satisfactory electrical logs when using such fluids.

It is therefore an object of this invention to provide a drilling fluid which combines the good properties of the water-base and of the oil-base drilling fluids without having their disadvantages.

Accordingly the present invention provides a drilling fluid for wells such as oil and gas wells, comprising an aqueous liquid, a finely divided solid material such as clay dispersed in said liquid and a

mineral or vegetable oil, emulsified in said liquid.

It has been found that such a fluid can be obtained and successfully used in drilling wells by forming a water-base drilling fluid and emulsifying a mineral or vegetable oil in said fluid. Preferably an emulsion of a crude petroleum oil is emulsified in a water-base drilling fluid.

In practising the present invention, it is preferred to start with an ordinary water-base drilling fluid, such as a suspension of clay and/or bentonite in water, whose viscosity may be controlled by means of chemical agents such as polyphosphoric acid salts, for example pyrophosphates, tetraphosphates, hexametaphosphates, etc., or basic solutions of substances such as tannins, lignins, ulmins, humins, etc. Preferably an emulsifying agent is added to the fluid with the application of heat and a crude oil is emulsified in said fluid. The specific gravity of the fluid may at the same time be controlled by adjusting the amount of the solid material suspended or dispersed therein, or by adding thereto additional weighting materials, such as calcium carbonate, barytes, galena, iron oxide, etc. Materials such as flake mica, asbestos and the like may also be added to the fluid, particularly when drilling through fractured or creviced formations to prevent excessive losses of the fluid to said formations. To this fluid there is added, according to the present invention, a mineral or vegetable oil and an agent to emulsify this oil in the water base fluid.

As a mineral oil, there may be used any petroleum or coal tar distillate oil, for example crude oil, gas oil, stove oil, diesel oil, etc. However, both from the economic standpoint, and from the standpoint of obtaining emulsions of stable properties having the desired plastering and specific gravity characteristics, it is greatly preferred to emulsify in the manner described above a heavy crude oil, such as a crude oil having a gravity of from 12 to 20° A.P.I.

As emulsifying agents, any of the commercially available emulsifiers such as listed by J. F. Van Antwerpen (Ind and Eng. Chemistry, Jan. 1941, pp. 16—21) may be used. The following agents are recited below by way of example as being especially effective: alkyl and aryl sulphonates, sulphated oils, fatty acids, glyceryls and alcohols, etc.; fatty acid soaps and their derivatives, such for example as oleic, linolic and linolenic acid soaps, tall oil, pine oil, etc., and their soaps, sulphite liquor rosin acid derivatives, naphthenic acid soaps, alkaline silicate and metasilicate compounds, polyphosphate compounds, such for example as pyrophosphates, sea moss or weed extracts such as alginates, algin soaps, etc., extracts of substances such as tannins, humins, lignins, ulmins, and more particularly substances or their extracts such as quebracho, agar, divi-divi, gum tragacanth, etc., used with caustic or basic-reacting agents, or any suitable mixture of the above-recited compounds.

The amounts in which these emulsifiers are added depend on the character of the mud, the properties desired of the emulsion, and the type of emulsifier used. Normally, an amount of from 0.1 to 2.0 per cent. on the weight of the water-base fluid should be used.

It will be noted that some of these agents may already be present in the water-base drilling fluid, being added thereto as viscosity-reducing agents or to increase plastering properties. In such cases it may be merely necessary to add some basic-reacting agent such, for example, as caustic soda or sodium metasilicate, or both together with the oil when emulsifying the latter, and any further addition of these agents is doubly effective in that they act both for the control of the viscosity and for the emulsification of the fluid.

The proportions in which the oil is mixed with the water-base fluid depend on the particular properties desired from the resulting emulsion, and on the specific gravities of the water-base fluid and of the oil. In general, these proportions vary from 25 per cent. oil and 75 per cent. water-base fluid to 75 per cent. oil and 25 per cent. water-base fluid, all percentages being by volume. For example, a drilling emulsion comprising 25 per cent. of heavy crude oil and 75 per cent. of an aqueous clay mud weighing 85 lbs. per cubic foot gives a drilling emulsion weighing about 79 lbs. per cubic foot. If the amount of crude oil is raised to 50 per cent., a drilling emulsion weighing about 72 lbs. per cubic foot is obtained.

By comparison with ordinary clay-water drilling fluids, the present drilling emulsions give a relatively high viscosity reading with the Marsh Funnel or the Stormer Viscometer, and a disproportionately low reading with the McMichael Viscometer. It may be noted that the same anomaly is observed with ordinary oil-base muds, and is probably due to the lubricating effects of the oil, which make the present drilling emulsion highly suitable for actual use in wells, even in cases where the measured viscosity appears to be excessively high. Thus, in a case where the present drilling emulsion was too thick to run through the Marsh Funnel, the circulating pressure

was normal upon the starting of the operations, namely a pressure of about 1000 lbs. per sq. in., with a 20 inch, 6½ inch liner pump at 45 strokes per minute in a well having a 4½ inch drill pipe to 8160 feet in an 8½ inch hole, the well having a 9⅝ inch casing to 6,845 feet.

The viscosity temperature coefficient of the present drilling emulsions is very good as compared with that of ordinary oil-base muds, that is, the viscosity of the present emulsions is not affected or reduced as greatly as that of the oil-base muds by the high temperatures prevailing deep underground.

Thus, in an area where frequent cavings of shale and sticking of the drill pipe in contact with nodular concretions of clay ironstone were extremely frequent, two adjoining wells were drilled, the first with an ordinary oil-base mud, and the second with the present drilling emulsion.

In the first well, the hole could not be kept clean due to the low carrying power of the oil-base mud, whose viscosity was greatly reduced by a bottom hole temperature of about 200° F. Large pieces of shale thus kept accumulating in the borehole, with the result that several hundred feet of sediment had to be cleaned out after each round trip, which greatly slowed down the drilling.

The second well was drilled to 6,860 feet with an ordinary water-clay mud weighing 88 lbs. per cubic foot. After cementing at this level, the same water-base mud was circulated in the well, and a solution comprising about 0.2 per cent. of caustic soda, 0.4 per cent. of sodium metasilicate and about 0.2 per cent. of divi-divi, calculated on the weight of the water-base mud, was added during circulation. A heavy crude oil was then added to and thoroughly admixed with the water-base mud by means of a mud-gun in the pit. A sufficient amount of oil was added to obtain an emulsion with a water-base mud to oil ratio of 2 to 1 by volume. The weight of the resulting emulsion was 77 lbs. The mixing time was about 8 hours, which is considerably less than that necessary for the preparation of a corresponding quantity of oil-base mud.

No heaving or caving took place during drilling with this emulsion, and the condition of the well when the completion depth was reached was much better than that of the first well, or of the other wells drilled with oil-base muds in the same area. Cuttings brought out with the drilling emulsion returns were of large size. Since the necessity for periodically cleaning up the well was thus eliminated, and since moreover the present emulsion lubricates the bit and prevents it from balling up, that is, from becoming clogged with the cuttings, a considerably higher drilling speed was achieved in this case, as will be seen from the following tabulation:

TABLE I.

Well Type Mud	Starting Depth	Final Depth	Interval Drilled (Shale)	Drilling Time
No. 1 Oil Base	6,883 ft.	7,546 ft.	663 ft.	9 days
No. 2 Drilling Emulsion	6,860 ft.	7,956 ft.	1,096 ft.	8 days

The gel strength of the present emulsions is very good, being increased by the addition of basic-reacting compounds, and decreased by the addition of compounds having an acid reaction, such for example as divi-divi, quebracho, etc. These substances may therefore be used for the control of the gel-forming and thixotropic properties of the present emulsions.

The plastering properties of the present emulsions are also very good, and remain so at high temperatures and pressures, the mudsheath formed thereby being extremely thin and substantially impervious to fluid loss. Due to the oily nature of said sheath, it is especially impervious to water flow. Therefore, although the present emulsions have water as the continuous or external phase, and oil as the discontinuous phase, the water of the emulsion has substantially no effect on the heaving shale layers traversed by the well. These excellent plastering properties are illustrated in Table II, which relates to three emulsions formed from three different water-clay muds, each treated with 0.5 per cent. caustic soda, 1.0 per cent. sodium silicate and 0.5 per cent. divi-divi on the weight of the water-base mud.

TABLE II

Mud	Volume Ratio Clay Mud	Oil	Weight lbs./cu. ft.	Filter Loss Ml./30 min.
No. 3	5	4	69	0.6
No. 4	5	4	75.5	3.5
No. 5	4	4	71	3.5

The electrical resistivity of the present drilling emulsions varies with the particular compositions used, but in general has an average value of about 200 ohms m/m². Excellent electrical logs may therefore be obtained in the wells drilled with or containing said emulsions, without having recourse to special type electrodes normally used for oil-base mud wells. Thus, in the well referred to hereinabove as well No. 2, a Schlumberger survey was made with ordinary electrodes when the completion depth of 8,162 ft. was reached, the electrical log obtained comparing favorably in accuracy and detail with logs obtained in the same area in wells drilled with water-base fluids.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A drilling fluid for wells such as oil and gas wells, comprising an aqueous liquid, a finely divided solid material such as clay dispersed in said liquid and a mineral or vegetable oil, emulsified in said liquid.

2. A drilling fluid as claimed in claim 1, comprising a crude oil and an emulsifying agent for said crude oil.

3. A drilling fluid substantially as described.

4. In the art of drilling oil and gas wells, the process comprising circulating in the borehole a drilling fluid as claimed in any one of the preceding claims.

5. A method of preparing a drilling fluid as claimed in claim 1 or 2, comprising the steps of forming a water-base drilling fluid and emulsifying a mineral or vegetable oil in said liquid.

6. A method as claimed in claim 5, comprising the steps of forming an aqueous suspension of clay, adding an emulsifying agent to said fluid with the application of heat and emulsifying a crude oil in said fluid.

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